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occasion nearly an entire box of the best plates in my endeavor to secure a picture of a pair of nestling Pewees (*Contopus virens*) in their nest. In the pictures the birds looked as though they had been *snowed on.* Cutting off the light from above in a later attempt rectified this defect. One good way to study the effect of the light, is upon the ground glass of the camera, when the subject has been carefully focused upon it—and I think it will be found a safe rule in many cases to make the exposure when a light cloud partially veils the sun's face. All such matters, however, can only be gained by experience; and to pass through this, the best of all schooling, one must be pre-armed with an enormous stock of the best kind of patience, with a slight reserve fund of the same article on hand in the event of a run upon the original supply.

The picture of the Cedar Birds taken in this way is reproduced in Plate I, January number of the NATURALIST.

THE BACTERIAL DISEASES OF PLANTS: A CRITICAL REVIEW OF THE PRESENT STATE OF OUR KNOWLEDGE.

BY ERWIN F. SMITH.

(*Continued from p. 41.*)

VI.

III. THE POTATO (SOLANUM TUBEROSUM L.)

1. THE GAS-FORMING WET-ROT OF THE TUBERS (1891).

(I) THE DISEASE:

(1) *Author, Title of Paper, Place of Publication, etc.*—This disease was studied by Dr. Ernst Kramer in 1890–91. His paper, entitled (40) *Bakteriologische Untersuchungen über die Nassfäule*

der Kartoffelknollen may be found in *Oesterreichisches landwirtschaftliches Centralblatt*, Jahrg. I, Heft 1, 1891, pp. 11–26, 2 text figures.

The rot of the potato has been known to the agriculturist for a long time and was described by Julius Kühn as early as 1830. Since that time it has been noticed or written upon extensively by many persons, *e. g.*, de Bary, Hallier, Reinke and Berthold, van Tieghem, Sorauer. For a time owing chiefly to the writings of de Bary, its ravages were confounded, especially in the popular mind, with those due to the potato mildew, *Phytophthora infestans*, but it has no necessary connection with this fungus although in Europe, at least, it usually follows the latter. Prior to Dr. Kramer's investigation the organism associated with the rot was usually considered to be *Bacillus amylobacter* van Tiegh. and this was supposed to be the same as the *Vibrion butyrique* of Pasteur, *Bacterium navicula* Reinke and Berthold, *Amylobacter clostridium* Trécul, *Bacillus butyricus* de Bary and *Clostridium butyricum* Prazm., but no one had approached the problem from a purely bacteriological standpoint using approved methods of isolation and inoculation.

The object of the author in undertaking this series of experiments was to determine first of all whether the wet rot was actually due to bacteria and, if so, how they gained entrance into the tuber; second, to identify the species and determine its morphological and biological peculiarities; third, to determine what decompositions it was capable of producing in the potato and in other substrata. Owing, says Dr. Kramer, to the fact that several bacteria cause the butyric fermentation and several color blue with iodine and agree in morphological particulars more or less closely with *Clostridium butyricum* Prazm. (*Bacillus butyricus* de Bary) "it appears still very questionable whether the specific cause of the wet rot is *C. butyricum* Prazm., especially as the predicated cause was not studied critically in relation to its morphology and biology by the above named investigators [Reinke and Berthold, van Tieghem, Sorauer]."

(2) *Geographical Distribution.*—Potato rot occurs in many parts of the world, in fact almost wherever the potato is cultiv-

ated, but by no means all of it is due to the particular organism isolated by Dr. Kramer, as the writer of this review has proved conclusively (see next review). Considering the readiness with which almost all bacteria grow upon cooked potatoes it seems not unlikely that even in its natural state the potato tuber may offer a suitable nidus for the growth of a variety of bacteria especially when it is kept unduly warm and moist. However, this may be, only two bacterial diseases of the potato have been worked out conclusively. The distribution of Dr. Kramer's wet rot of the potato is not known. Very likely it occurs in North America as well as in Europe but no one has established this fact, probably because no one has searched for the organism, his paper having been very generally overlooked. Even the European distribution of this rot is a matter of much doubt as it has probably been confused with the brown rot due to *Bacillus solanacearum.*

The potatoes from which were derived the bacteria used in these experiments came from the vicinity of Graz where the wet rot was very destructive in the autumn of 1890.

(3) *Symptoms.*—Under the influence of this disease the contents of the tuber becomes soft, pulpy, vile-smelling, and usually of a yellowish color. The disease may either attack the tubers before they are harvested or during the winter in the store houses. If one of these wet rotten tubers is pricked or squeezed a fluid pours out which has a strongly acid reaction and a very bad smell, mostly like butyric acid. Gas bubbles are also frequent. The remaining pulp, which is rather compact, gives an alkaline reaction either immediately or after a short time. This reaction is plainest in the tissues which have already become completely pulpy. At the commencement of the destruction of the potato while the tissue is still firm, the reaction is moderately acid.

The tubers forwarded to Dr. Kramer for investigation possessed all the above mentioned characteristics of wet rot. They still had a plump look. The skin was apparently uninjured but the whole potato was a bloated sack with a yellow ichorous contents. When punctured a very bad smelling, sour fluid escaped. The smell recalled butyric acid and amin bases (trimethylamin). In some cases the escaping juice as well as the remaining pulp gave at first an acid reaction and subsequently an alkaline reaction.

(4) *Pathological Histology.*—Under the microscope the fluid pulp appeared to be composed of starch grains, single cells of the potato, or groups of such cells, fragments of cell walls, remnants of protoplasm, and countless numbers of bacteria, chiefly in the form of bacilli, These measured 1.5–5.0 x 0.8μ, and were actively motile. Frequently they appeared as though composed of non-septate threads, or were in chains. The single rods were rounded at the ends, while not rarely the longer threads appeared to be narrowed toward the extremity (zugespitzt). Ellipsoidal forms, 1 x 2μ, appeared regularly among these bacilli. A roundish, strongly refractive body was visible in the protoplasm of these ellipsoidal forms. This represented the beginning of spore formation, as was shown by later and more exact investigation.

(5) *Direct Infection Experiments.*—No direct infections.

(II) THE ORGANISM: Described as a bacillus but not named.

I have been in the habit of calling this organism Kramer's potato bacillus, and until such time as it can be re-studied and carefully compared with other gas and acid producing species it is probably best that it should remained unnamed. Some critical student of the species is certainly the only one who has any right to name it. We have had altogether too much of naming things without study, *i. e.* on the strength of the imperfect descriptions of other writers.

1. *Pathogenesis:*
   (A) Yes.
   (B) Yes. This was accomplished in the following manner. Wet rotten tubers having the skin still uninjured were cut open with sterilized knives and small quantities of the fluid pulp were transferred by means of a sterilized platinum loop into flasks closed by cotton plugs and half full of distilled, sterilized water, which was then well shaken to distribute the bacteria. To obtain a proper dilution definite quantities of this infected water were transferred to similar flasks, each

half full of sterilized water. From these second dilutions, the inoculations were made. The bacteria were isolated by the poured plate method, dextrose-peptone, nutrient gelatine being first used as à substratum, and subsequently nutrient glycerine agar which proved very satisfactory.

(C) Yes. The method of infection was as follows. The bacillus was first cultivated in a variety of fluid media until a suitable one was found. A watery potato juice with the addition of 1–2 per cent dextrose was finally selected as most suitable, the bacillus developing better in this than in any other medium. This broth was made as follows: Fresh potatoes were reduced to pulp and digested for some hours in cold water. The fluid was then filtered out and the dextrose added. The filtrate was then boiled, filtered again, and finally sterilized in the ordinary way under cotton plugs. A series of glass dishes (Präparatengläsern), about 8 cm. deep and 10 cm. broad, were filled half full of this broth. These dishes were closed by corks having a short, cotton-plugged glass tube passing through them. The vessels with the enclosed nutrient fluid were then sterilized by discontinuous heat. The potatoes to be tested were selected with great care, and their surface was sterilized as far as practicable in the following manner. These living tubers were first cleaned mechanically, then plunged for some minutes into a solution or mercuric chloride, and finally washed repeatedly in sterilized, distilled water. In this way some of the tubers (not all of them) were rendered completely sterile. The tubers were then placed in the sterilized broth in the glass dishes, the mass of the fluid having been so chosen that when the sterilized tubers were in place they were entirely covered by the broth. The fluid was then inoculated with small quantities of the bacilli, derived from pure cultures, by removing the cotton plug from the glass tube for a moment and inserting the germs on the end of a sterilized platinum wire. The vessels were then placed in a brood oven at a temperature of 35°C. Within 12 hours the nutrient fluid became very turbid and began to give off gas bubbles rapidly.

After 8 days three vessels were opened and the potatoes taken out. Tubers and broth were examined immediately. In places the skin of the tubers exhibited folds and the tissue underneath appeared to be soft. When these spots were cut out and examined microscopically the entire tissue was found to be honeycombed, the intercellular substance being strongly swollen or entirely dissolved, the cell membranes wholly or partially destroyed, and the starch grains free in places.

After 14 days more vessels were opened and the potatoes removed. Under the skin of these tubers there were very soft spots and exact investigation showed that in these places the tissue was almost entirely destroyed so that great cavities were formed. The softened tissues surrounding these cavities gave a faint acid reaction and contained numerous bacteria.

Finally, after 20 days, the remainder of the potatoes were removed from the broth and examined. By this time the appearance of these tubers had entirely changed. They consisted only of bloated sacks filled with a half fluid pulp. Exactly as in case of the original wet rotten tubers the contents consisted of free starch grains, single cells and groups of cells, cell membranes, remnants of protoplasm, and myriads of bacteria. The fluid pulp gave a strongly acid reaction and had a smell like butyric acid. When such tubers were pressed, gas bubbles came out. Taken out of the nutrient fluid and kept in a damp chamber at 25°C., the tubers rapidly underwent a still further decay. After 12 hours the smell of butyric acid disappeared and the tissues showed a strong alkaline reaction, accompanied by a smell recalling ammonia and amin bases.

Checks did not develop this rot. In sterile water they either remained sound for weeks or else, in case the skins were not thoroughly sterilized, contracted a different kind of decay, due chiefly to *Bacillus fluorescens*.

(D) Yes. In case of the tubers which were in the fluid 8 days the softened spots contained large numbers of bacteria (bacilli), which, when critically examined, turned out to possess all the morphological and biological characters of the bacteria obtained by pure cultures from the wet rotted potatoes, and from which the nutrient solutions had been inoculated. At the same time that the tubers were examined the solutions were subjected to an exact bacteriological investigation. In two instances no other bacteria were found in them than the sort which had been put in purposely. In the third case, several other bacteria were present, indicating that the skin of the tuber had not been completely sterilized.

In case of the tubers which remained in the fluid 14 days, the bacteria in the softened tissue around the cavities were isolated and found to be identical with those used for inoculating the fluid. In two cases also, only the inoculated form was obtained in cultures made from the nutrient fluid surrounding these tubers, and consequently there could be no doubt that the destruction of the tissues was due to these bacteria. Similar cultures were made from the tubers left in the broth 20 days, and with the same results. When cultivated out, the bacteria swarming in the rotten tubers proved to be morphologically and biologically identical with the form originally inoculated into the nutrient solution in which the tuber lay, and from which alone the infection could result. In brief, the previously sound potatoes became infected and wet rotten as a result of the action of the bacteria introduced into the nutrient solution, and these bacteria had been previously cultivated pure from wet rotten potatoes.

Conclusion.—Pathogenic nature clearly established.

Remark.—"The objection may perhaps be raised that the artificially induced wet rot, just described, did not begin with infection from without, *i. e.* from the nutrient solution, but that bacteria were present in the apparently sound tissue of the potatoes used for the experiment, *i. e.* foci of infection dating from the harvest time, which later on with higher temperature and sufficient moisture, developed further. In opposition to this it may be stated, first, that the potatoes used in the experiment came from a locality in which, in previous years, wet rot had not appeared; and, second that the tissue of several of these potatoes was tested for the presence of bacteria, but always with negative results. The infection was also transmitted to sound tubers by puncturing them with a sterile platinum wire and then inserting into the stab a slight quantity of a bacterial, pure culture. These tubers were kept in a damp chamber at 35°C. The decay of the tuber, which always proceeded from the inoculation puncture, was identical with that of the wet rotten tubers. The wet rot of the potato tuber is, therefore, nothing but a decomposition of the same induced by a particular species of bacteria. Sorauer, and van Tieghem performed similar experiments but these differ from my own in that the investigators I have mentioned worked neither with bacterial pure cultures nor with sterilized tubers and sterilized nutrient fluids."

There is another objection which does not seem to have occurred to Dr. Kramer, viz., that the tubers which rotted were exposed to abnormal conditions. They were either submerged or placed in very moist air and quite likely deprived of their vitality through lack of aeration. They were also exposed to an unusually high temperature. Under these conditions, which would occur in the potato fields only exceptionally as the result of exceedingly hot weather and of very frequent or very prolonged rains, possibly many other organisms, which are usually saprophytic, might enter and destroy the tubers, lying in the warm, wet earth. This seems to be established by Dr. Kramer's own experiments (see last paragraph under (II) 1 (C.). He has shown clearly that the species in question will produce wet rot, but not that many other species would not also produce it under like conditions. A much severer test of the parasitic nature of this organism would be the inoculation of the growing leaves and stems of the potato under normal conditions of temperature and moisture, simply by means of needle pricks. Under these conditions it is possible the organism might be shorn of much of its power or refuse to grow altogether. The determination of this point offers an interesting field of experiment for some one.

2. *Morphology:*

(1) *Shape, size, etc.*—This organism is described as a Bacillus. It forms rods 2.5–4.0 x 0.7–0.8 μ. On gelatine and agar plates chains are common, as are also apparently non-septate threads which frequently reach a length of 16 μ. and more. In nutrient fluids and on potato the rods are for the most part shorter, *i. e.* 1.5 to 2.0 μ. long. The rods are rounded at the ends. The threads taper off and are wavy. Spindle-shaped organisms could not be found.

(2) *Capsule.*—No mention of any capsule.

(3) *Flagella.*—The rods are actively motile. No mention of flagella.

(4) *Spores.*—Thicker, ellipsoidal forms occur in old cultures. These are 1.3 x 2.0 μ. They have a strongly developed membrane and their plasma becomes differentiated and more strongly refractive. This is the commencement of spore formation. The mature spores fill the whole interior of the cell.

(5) *Zoogloœa.*—No mention of zooglœa.

(6) *Involution forms.*—No mention of any distorted forms.

3. *Biology:*

(1) *Stains.*—The vegetative rods take all the common anilin stains, and the spores may be colored very prettily by Neisser's method.

(2) *Gelatin.*—On plates of nutrient gelatin the organism forms dirty-white colonies, around the periphery of which the gelatin

liquefies allowing the colony to settle to the bottom of a pit. The funnel of liquefaction extends rapidly over large areas of the plate. Owing to this rapid liquefaction successful gelatin plates can be made only by very thin sowings. In most cases, the whole plate was soon liquefied at 25° C., if somewhat abundant sowings were made. In stab cultures, dot-formed colonies first develop along the track of the needle and finally fuse so that the stab appears as a thread. The liquefaction begins at the mouth of the canal and proceeds very energetically so that ordinarily in 48 hours at 25° C., the whole gelatin has become fluid. Streak cultures on nutrient gelatin are very characteristic. Within 12 hours the track of the needle appears as a raised dirty white line. The line spreads rapidly and widely to each side, forming a surface not unlike an elongated, irregularly margined leaf. Scarcely has this leaf formed when the gelatin begins to liquefy. Such streak cultures can be carried on only at room temperatures and with inoculations from cultures that have been grown on gelatin repeatedly; otherwise, the gelatin is liquefied too quickly.

(3) *Agar.*—On plate cultures of nutrient glycerin agar the organism forms small, dirty-white, slimy drops. When examined with a hand lens these appear to be round, have a sharp contour, and show in the interior a brownish center. In stab cultures the track of the needle appears as a thread, and the organism spreads from the mouth of the canal toward the periphery as a delicate layer (Auflagerung).

(4) *Potato, etc.*—On potato it forms a dirty-white, slimy layer, which at first gives an acid reaction, and then becomes strongly alkaline. The decomposition proceeds rapidly through the whole slice of potato, 2 to 3 days, at 25° C., being sufficient to involve the whole thickness. During this decay there is a copious evolution of gas from the interior, bubbles as big as a pin head bursting through the slimy covering and leaving in it little funnel shaped openings.

(5) *Animal Fluids.*—Judging from statements cited under *Pathogenesis* C., probably several were tried but there is no specific mention of anything but milk. In this fluid the organism caused the separation of the casein but no other

change. Unlike Hueppe's aerobic *Bacillus butyricus* it caused in the milk no formation of ammonia, leucin, tyrosin, and a bitter tasting substance, when kept at 25° C.,—not even after three weeks.

(6) *Vegetable Juices.*—This germ grew best of all in cooked potato juice to which 1–2 per cent of dextrose was added. At 35° C., this fluid became very cloudy in 12 hours and gas bubbles were given off.

(7) *Salt solutions and other Synthetic media.*—In dextrose solutions with addition of tartrate of ammonia or peptone and the necessary mineral substances (not stated what) the organism developed very satisfactorily with formation of carbonic acid and butyric acid. In a starch paste to which tartrate of ammonia and the common nutrient salts were added, the organism grew well but there was only a slight dissolving of the starch and no formation of butyric acid. For behavior in mineral solutions containing 5 per cent peptone see *Biology* 10 c.

(8) *Relation to Free oxygen.*—*Bacillus amylobacter* (*Clostridium butyricum* Prazm.), as is well known, grows only on exclusion of the air, and since the wet rot of the potato was generally attributed to this organism, Dr. Kramer first started anaerobiontic cultures. The inoculated nutrient dextrose-peptone gelatin was poured into plates and covered with films of mica. At the same time anaerobiontic cultures were started in Gruber's tubes, using dextrose-peptone, nutrient gelatin. The cultures were kept in a brood oven at 26° C. The colonies began to appear in 24 hours. On the plate cultures under the mica, after 48 hours, tiny colonies appeared which did not increase in size to any noteworthy extent. Colonies on the same gelatin, uncovered, developed rapidly, so that on the second day this was entirely liquefied. The liquefied gelatin smelled like butyric acid, *i. e.*, distinctly like sauer-kraut. In Gruber's tubes minute, dot-like colonies also appeared, but only a few of these developed any further. The larger colonies caused a circular liquefaction of the gelatin, 2–4 mm. broad and increasing but slightly. These experiments indicated that the organism is not anaerobic. A more careful examination of the

colonies in the Gruber's tubes showed that every colony buried in the gelatin was unable to develop further, and that only a few of the superficial ones reached a somewhat larger size and liquefied the gelatin. Evidently a slight quantity of oxygen remained in the tubes (it is impossible to pump out all the air) and this sufficed for the development of some of the colonies. The tiny, dot-shaped colonies under the mica, those in the Gruber's tubes, and those which produced liquefaction on the uncovered gelatin were then studied carefully and found to be all of one sort. They were bacilli agreeing exactly in their morphological characters with the rods which had been observed previously in the wet rotten tuber. That the dot-shaped colonies in the Gruber's tubes failed to develop further simply from lack of oxygen is best shown by the fact that after the opening of the tubes the growth of the colonies and the liquefaction of the gelatin proceeded so rapidly that within 12 hours the latter was completely liquefied, even at room temperatures.

(9) *Reducing and Oxidizing Power.*—In stab cultures in nutrient gelatin rendered blue by tincture of litmus, a confluent, dirty-white growth was formed in the canal, and at the same time the gelatin began to change from blue to red, commencing at the upper end of the stab. When this reddening had reaching the bottom of the tube the gelatin began to liquefy commencing at the upper end of the stab. Along with this liquefaction there was a complete bleaching of the litmus, the gelatin resuming its original yellow color. It could not be determined whether this reduction should be referred to removal of oxygen or to the liberation of hydrogen. Nutrient gelatin stained red by carminic acid was also entirely bleached by this bacillus.

(10) *Fermentation Products and other Results of Growth:*

(a) *Gas Production.*—The organism causes a copious evolution of gas from potato tubers, living or steamed ; potato broth with dextrose; and dextrose solutions containing ammonium tartrate and mineral salts. This gas was determined to be CO_2. No mention is made of any hydrogen. Possibly some was overlooked.

(b) *Formation of Acids.*—The bacillus produces a strong acid reaction in solutions or substrata containing sugar, *i. e.*, in the potato; in steamed potato juice with addition of 1–2 per cent dextrose; and in dextrose solutions containing tartrate of ammonia and the necessary mineral substances; but not in starch paste with ammonium tartrate and the nutrient mineral substances, nor in peptone solutions containing nutrient mineral substances. This acid was determined to be butyric and in the following manner. The soft contents of a tuber in the first stage of rot while still acid, was extracted in water by boiling, filtered, and mixed with a small quantity of calcium carbonate. A white precipitate resulted, presumably of calcium butyrate. This was, consequently, filtered boiling hot. The precipitate which crystalized out of the liquid exhibited under the microscope the very characteristic rhombic prisms of calcium butyrate. When this salt was mixed with dilute hydrochloric acid a fluid resulted which was miscible in water, had a boiling point of 163° C., and possessed the characteristic smell of butyric acid.

(c) *Production of Alkali.*—In the second stage of the rot the tissues show a strong alkaline reaction. If a little of the soft contents of a tuber in this stage of the rot is mixed with a few drops of distilled water, the fluid filtered, and the filtrate mixed with Nessler's reagent, a decided brown color appears instantly, indicating ammonia. A part of this ammonia combines with the free butyric acid to form ammonium butyrate and the remainder serves to render the decomposed tissues strongly alkaline. The ammonia is attributed to the decomposition of albuminoid substances by the bacillus. As additional evidence, it is stated that if a 5 per cent peptone solution containing the necessary nutrient mineral substances be inoculated with a pure culture of this bacillus, a sort of rotting fermentation takes place, the first evidence of which is a strong ammoniacal smell. Nessler's solution indicates the presence of ammonia.

(d) *Formation of Pigment.*—Growth described as dirty-white on agar, gelatin, and cooked potato.

(e) *Development of Odors.*—As already stated, there is a strong odor of butyric acid in the first stage of the rot, and subsequently other bad odors appear. The latter are due to ammonia, methylamin, and especially trimethylamin. The existence of the amin bases was determined as follows. Methylamin was found by taking a little of the thoroughly rotted tissue, mixing it with water, filtering, and mixing the filtrate with platinous chloride, whereupon there resulted a green precipitate, $PtCl_2\ 2CH_3\ NH_2$. Trimethylamin was detected by adding to a second part of the filtrate acid (salzsaures) platinic chloride, the resulting orange precipitate consisting only of the well developed octahedrons of the corresponding platinic double salt. The formation of these amin bases is attributed to the action of the bacillus on the nitrogenous part of the substratum. They were also detected by the same methods in the above mentioned mineral solution containing 5 per cent peptone, and consequently must have been derived from the peptone. These substances may also be detected in old pure cultures of this bacillus in peptone nutrient gelatin.

(f) *Enzymes.*—No mention is made of any study of these bodies. The organism undoubtedly produces several since it is capable not only of peptonizing gelatin and of dissolving cellulose but also of attacking albuminoids. Starch is but little affected.

(g) *Other Products.*—See *Biology* 10e.

(11) *Effect of Dessication.*—No statement. Probably not readily injured by dry air. Forms spores.

(12) *Thermal Relations:*

(a) *Maximum for Growth.*—Not determined.

(b) *Optimum for Growth.*—Not determined. This germ grows well at 25° C., and at 35° C., apparently most rapidly at the latter temperature.

(c) *Minimum for Growth.*—Not determined.

(d) *Death Point.*—Not determined.

(13) *Relation to Light.*—No statement.

(14) *Vitality on Various Media.*—No statement. The organism forms spores.

(15) *Effect on Growth of Reaction of Medium (acid, neutral, alkaline).*—No specific statement. Organism will evidently grow in either acid or alkaline media.

(16) *Sensitiveness to Antiseptics and Germicides.*—No statement.

(17) *Other Host Plants.*—No mention of any.

(18) *Effect upon Animals.*—No mention of any tests.

(III) Economic Aspects:

(1) *Losses.*—Serious.

(2) *Natural Methods of Infection.*—The question at once arises: How is the disease spread in the field, the tuber being, as is well known, carefully protected from external injuries by a firm layer of cork cells. If this layer is not punctured or broken the tuber appears to be safe from parasitic attacks. Even when the bacillus was placed on the cut surface of a living tuber in the air of an ordinary room, Dr. Kramer found that it was never able to cause the disease, the tuber developing a protective layer of cork cells under the mass of bacilli before they could grow. The case was quite different, however, when tubers lying in the infected nutrient solutions were stabbed with a sterile platinum wire. When, after 8 days, such tubers were examined by cutting through the stab, the canal in most cases was found occupied by the bacteria, and the decay of the tissue was seen to have proceeded from this canal outward. If the cork covering was shaved off in any place, the infection ordinarily began there. There is, consequently, no doubt that in the presence of sufficient moisture the bacteria can gain an easy entrance if the corky covering of the tubers is injured in any way, and such injury, we know, is frequently brought about by insects. It is well known also that the lenticels open when potato tubers are exposed to moisture for some time, *e. g.*, in wet earth, and this readily accounts for the infection of uninjured tubers. Indeed, Dr. Kramer demonstrated experimentally that in apparently uninjured tubers lying in his infected broths the rot frequently began with a darkening and softening around the lenticels, these changes being visible within a few days. When such spots were examinsd it was found that the bacteria had already penetrated into the tissue

in considerable numbers. Dr. Sorauer attributed the infection of sound tubers to this cause and Dr. Kramer was thus able to confirm it.

(3) *Conditions Favoring the Spread of the Disease.*—There is nothing on this subject beyond the statement that potatoes rich in sugar would be attacked and destroyed sooner than those rich in starch. It is clear, however, that this disease is likely to be most prevalent in warm and wet autumns, high temperatures and excessive rainfall offering favorable conditions for its development.

(4) *Methods of Prevention.*—No experiments, and no observations. Disease not studied in the field. Of course, whenever warm, rainy weather occurs in autumn potato rot of some sort is likely to appear, and common sense would dictate the prompt digging of the tubers and their storage in thin layers in a dry place, otherwise the whole crop may be destroyed in the ground, or subsequently in the pit or cellar.

Remark.—In the later stages of decay *Bacillus fluorescens* is quite common, and one is also likely to find almost any of the common soil bacteria. This paper was announced only as a preliminary communication, but no second paper has been published, so far as known to the writer.

This organism differs from *Bacillus amylobacter* van Tiegh. (*Clostridium butyricum* Prazm.) in that the latter is strictly anaerobic, produces spores in spindle shaped cells and colors blue with iodine. *Bacillus butyricus* Botkin, which is thought by Lehmann and Neumann (**41**) *Bakteriologische Diagnostik*, Munich, 1896, Bd., II, p. 315, to be distinct from the preceeding, is also strictly anaerobic. *Bacillus butyricus* Hueppe differs from Dr. Kramer's organism in the way metioned above (II) 3 (5) in the absence of gas production, and in some less important particulars. A number of other butyric acid forming species have been described but all more or less imperfectly.